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PRESS RELEASE

How our past shapes the present

How do we process and identify sensory stimuli? The perception of the ongoing stimulus, according to new research, is governed by preceding stimuli. The brain's algorithm for collecting and storing information, stimulus after stimulus, is the focus of a study that has just been published in Nature Communications.

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Our experience of the present is constructed through the recent past: this what a new study by the group of Mathew Diamond at SISSA, published in Nature Communications, demonstrates. The researchers have worked out the algorithms the brain employs to shape each new tactile sensation, as a function of the stimuli that have been presented earlier. The study's main result is quite simple, according to Diamond: "As we perceive the world, our history of experience creates a context for understanding the present."

MA PER SEGUIR VIRTUTE E CANOSCENZA • SISSA •

A mathematical model that predicts how “strong” or “weak” a vibration is

The Diamond team, which includes Iacopo Hachen, Sebastian Reinartz, Romain Brasselet, and Alisea Stroligo, first observed the phenomenon in rats, and then found that the exact same algorithms are at work in humans. The team investigated the influence of the intensity of preceding stimuli on the perception of the current stimulus.
They discovered that the strength of a brief vibration, delivered either on the subjects’ fingertips (in humans) or on the whiskers (in rats), determined how subsequent vibrations were judged. Based on these observations, the authors created a mathematical model that predicts how “strong” or “weak” one vibration will be perceived according to the individual’s recent sensory history.

Ongoing experiences are scaled to the stimuli which occurred within a particular window of the recent past

The findings offer a solution to a longstanding problem in the neuroscience of perception. Iacopo Hachen, first author of the publication, explains: “When we experience an event as loud, bright, weak, and so on, how is our measure of its intensity regulated? As we adjust to a quiet voice, how does our perception of volume adapt, so to allow us to grasp the words? The general rule, from our study, is that ongoing experiences are scaled to the stimuli which occurred within a particular window of the recent past.” Co-author Sebastian Reinartz, adds that “although the experiments and the mathematical model were restricted to the sense of touch, we are convinced that the algorithms will apply to other sensory modalities. We are now generalizing these studies to the hearing modality.”

Brief stimuli leave a trace in the brain

The experiments showed that brief stimuli, even if shorter than one second, leave a trace in the brain for almost a minute. These traces accumulate, generating a bias in perception. While such a bias might seem like a distortion of the environment, it turns out to be advantageous: information is collected over time, stimulus after stimulus, and the long-term trace allows subjects to fine-tune the sensory channel to a certain input range. Remarkably, the same mechanisms were uncovered both in humans and in rats, suggesting that the nervous systems of many species employ a similar fine-tuning machinery.
The impact of past stimuli varied between individuals: subjects whose memory stretched farther back in time to estimate the ongoing context showed higher accuracy in sensing the present stimulus. However, subjects with a long memory for the past also adapt more slowly when context changes. This suggests that

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relying too much on past sensory information can be disadvantageous in a situation where the context changes frequently.

Potential insight into psychiatric conditions that affect how people adapt to changes in the environment

The study's discovery of how ongoing perception adapts to recent history opens up new lines of research. When we are in environments where context changes frequently (for instance, moving back and forth between a noisy, crowded room and a quiet office) do the time constants that regulate sensory adaptation conform to the volatility of the environment? Or does the brain have one fixed, stable memory system? To answer questions like this, the research team will need to understand where in the brain such memories are stored, and how the memories interact with the representation of ongoing stimuli. The study also offers potential insight into psychiatric conditions that affect how people adapt to changes in the environment (e.g. autism), by offering a model to help explain this phenomenon: perceptual memory systems might remain "fixed" on one environment and fail to tune themselves dynamically as the surroundings change.

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